Contact Mechanics and Adhesion between Elastic Bodies with Randomly Rough

Dr. B.N.J. Persson
Institut für Festkörperforschung, Forschungszentrum Jülich, Germany

Abstract

Adhesion, contact mechanics, friction and wear are major problems limiting both the fabrication yield and operation lifetime of many microelectromechanical (MEMS) devices. Thus, a good understanding of microscale contact mechanics and adhesion in MEMS is fundamental for the design of such systems.

I have developed a theory of contact mechanics and adhesion between an elastic solid and a hard randomly rough substrate. The theory takes into account that partial contact may occur between the solids on all length scales.

I present numerical results for the case where the substrate surface is self affine fractal. When the fractal dimension is close to 2, complete contact typically occur in the macro asperity contact areas, while when the fractal dimension is larger than 2.5, the area of (apparent) contact decreases continuously when the magnification is increased.

An important result is that even when the surface roughness is so high that no adhesion can be detected in a pull-off experiment, the area of real contact (when adhesion is included) may still be several times larger than when the adhesion is neglected. Since it is the area of real contact which determines the sliding friction force, the adhesion interaction may strongly affect the friction force even when no adhesion can be detected in a pull-off experiment.

I also briefly consider adhesion relevant to biological systems, e.g.,flies, crickets and lizards, where the adhesive microstructures consist of arrays of thin fibers. The effective elastic modulus of the fiber arrays can be very small which is of fundamental importance for adhesion on smooth and rough substrates. I show how the adhesion depend on the substrate roughness amplitude and apply the theoretical results to lizards.